Diplomarbeitspräsentation der Fakultät für Informatik

FAKULTÄT FÜR !NFORMATIK

Faculty of Informatics

Reeb Graph Based Image Representation for Phenotyping of Plants

Masterstudium:
Visual Computing

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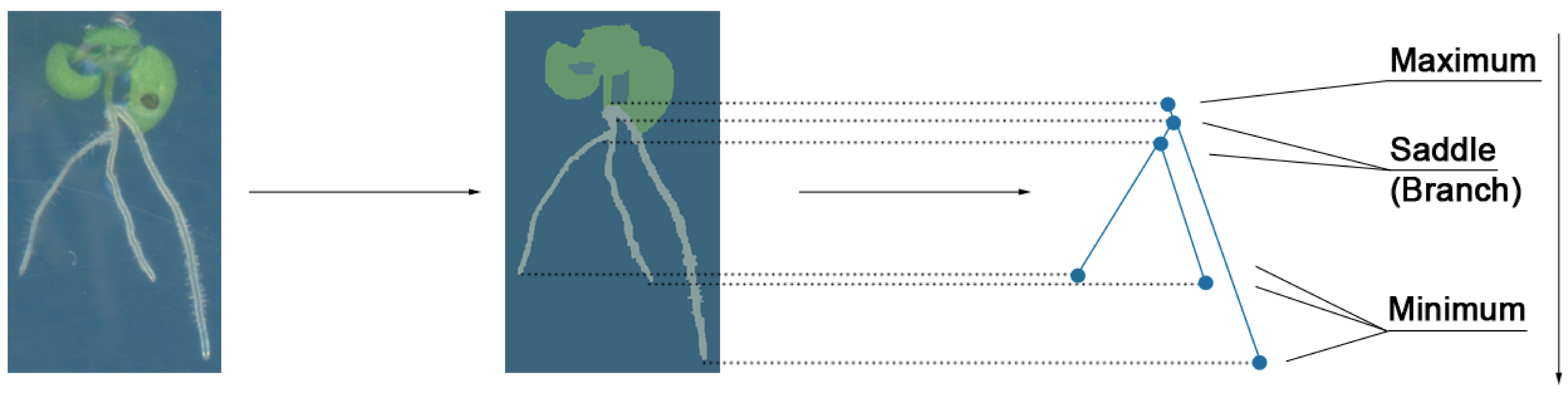
Introduction to Phenotyping

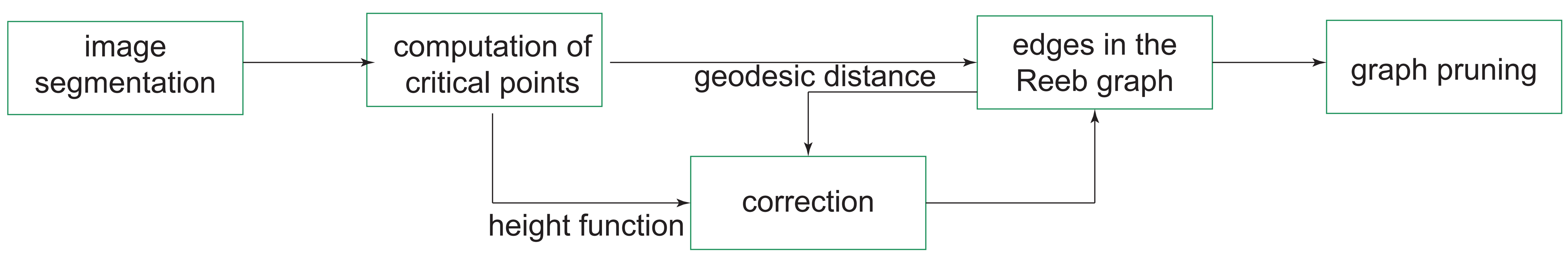
phenotype (Greek: phainein = to show) - composition of an **organism's observable characteristics**

phenotyping of the plant *Arabidopsis thaliana*:
- **characteristics of the root** such as **branching points and branch endings** are analysed
- these characteristics can be efficiently described by a skeletal graph representation

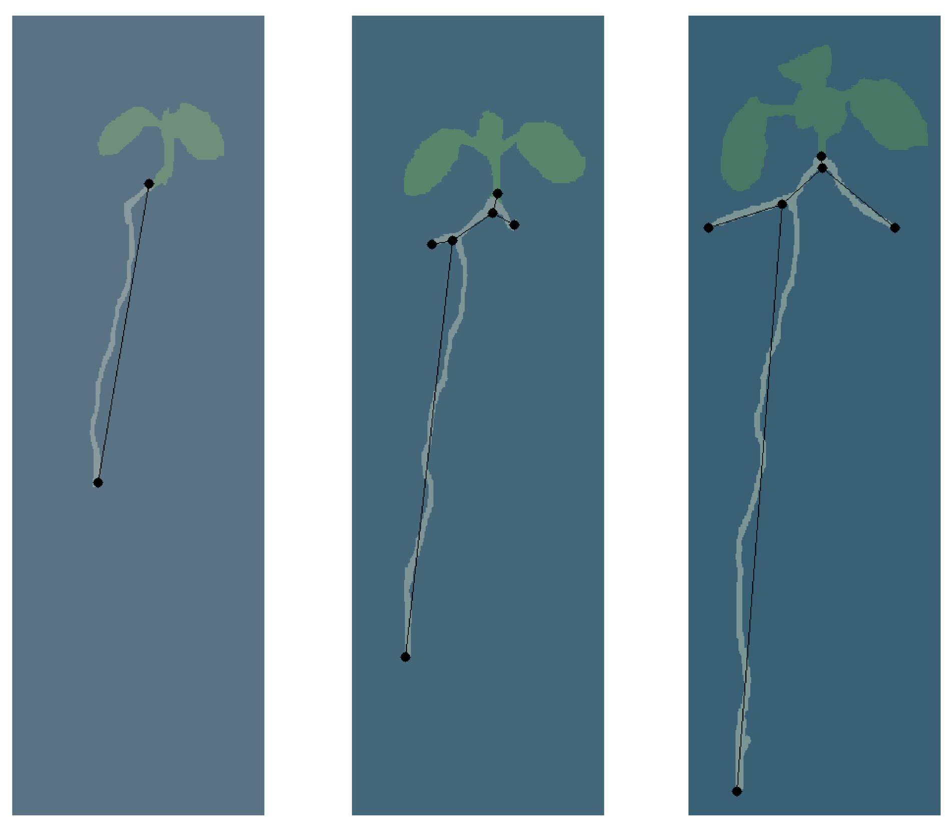
Reeb Graph Based Representation

Root characteristics described by **Reeb graphs** (according to **height function** and **geodesic distance**):
- Reeb graphs **preserve topological information**
- **nodes** in Reeb graphs correspond to **critical points** (branching points and end points of branches)
- **edges** in Reeb graphs describe **topological persistence** [1]
- 2D critical points (nodes in the Reeb graph) are minima, maxima, or saddles [2]
- Reeb graphs are **based on Morse theory** but have been extended to the discrete domain
- according to Morse theory: for all pairs of distinct critical points x_1 and x_2, $f(x_1) \neq f(x_2)$ holds true [2]





Results



root17, day 12 is a subgraph of root 17, day16

root17, day 16 and root 17, day 20 are isomorphic graphs

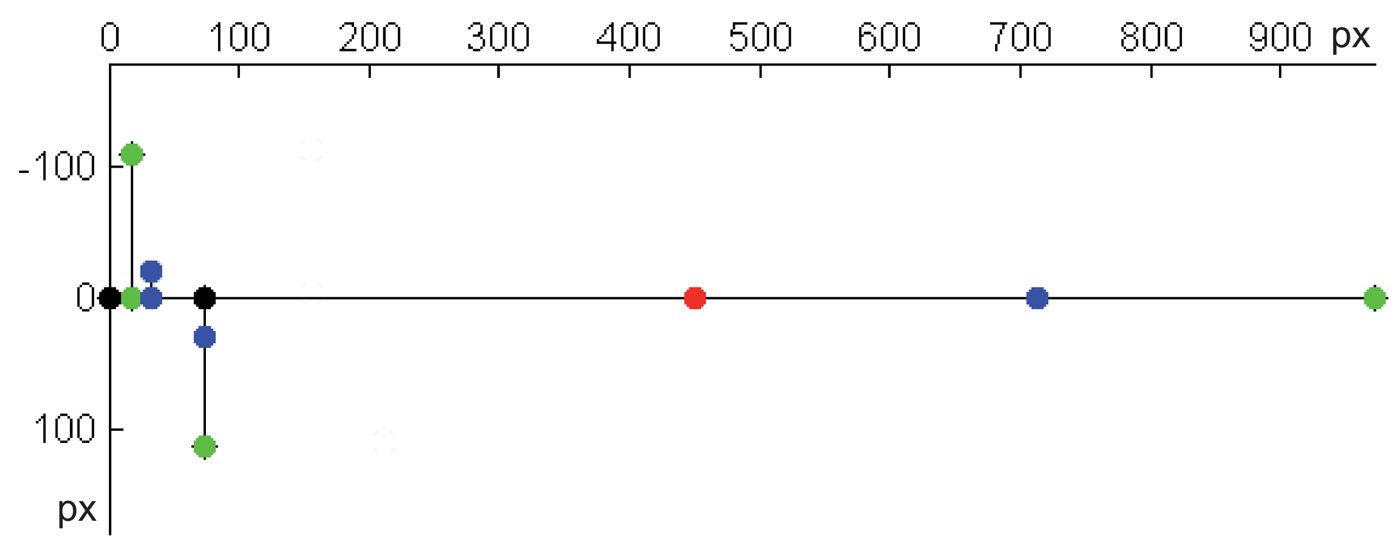
combination of graph representations through **isomorphic subgraphs**

distance between two graphs through **maximal common subgraph**

$$d(G_1, G_2) = 1 - \frac{|G_{mcs}|}{max(|G_1|, |G_2|)}$$

Structural equality of graphs				
	geodesic distance Reeb g.	height function Reeb g.	medial axis graph	
geodesic distance Reeb g.	100%	0.06	0.25	distance between graphs
height function Reeb g.	79%	100%	0.25	
medial axis graph	32%	26%	100%	
	isomorphic graphs			

based on a dataset of 34 root images



normalised root representation root 17, day 12, day 16, day 20

Conclusion

Reeb graphs:
- are **suitable descriptors** for root structures
- capture the **main characteristics of roots** well: **branches** and **branch endings** [3]
- branching points and **overlaps** by projection from 3D can be immediately distinguished (**cycle in the Reeb graph**)[3]
- the attributes of **different graph representations** can be **combined** for **isomorphic subgraphs**
- **normalised representation**: efficient **comparison** of **roots of different plants** or **on different days of growth**

References:
[1] S. Biasotti, D. Giorgi, M. Spagnuolo, and B. Falcidieno. Reeb graphs for shape analysis and applications. Theoretical Computer Science, 392(13):5–22, 2008.
[2] H. Doraiswamy and V. Natarajan. Efficient algorithms for computing Reeb graphs. Computational Geometry, 42(67):606–616, 2009.
[3] I. Janusch, W. G. Kropatsch, and W. Busch. Reeb graph based examination of root development. Proceedings of the 19th Computer Vision Winter Workshop, 2014.

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